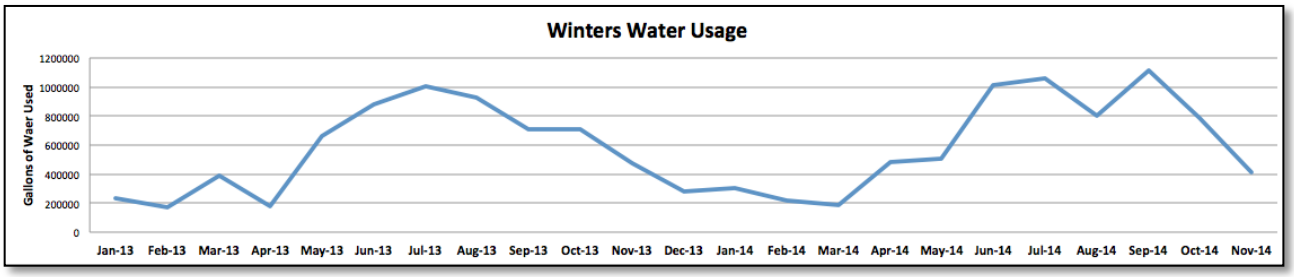
An Explantion of Calculation Methods to Determine Water and Energy Demand to Create Zero Net Water and Zero Net Electric Communities

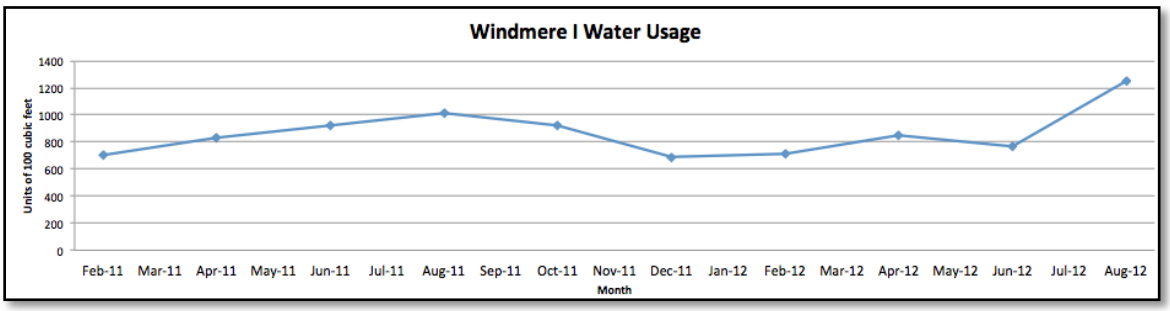
By Redwood Energy's Sean Armstrong and Michael Winkler

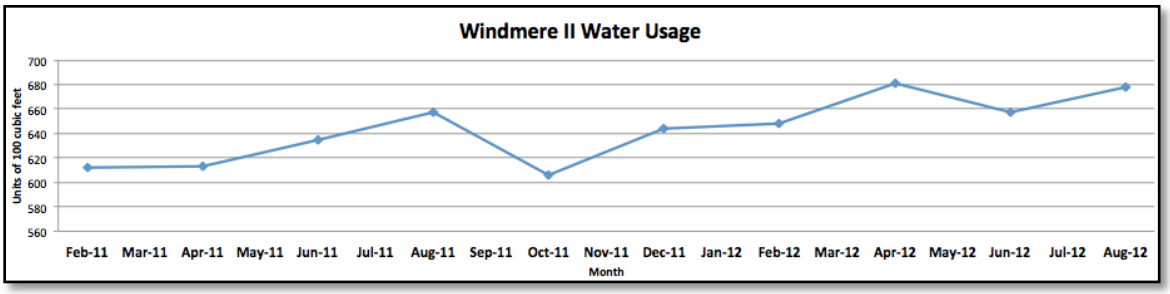
Water:

In order to establish the existing water use at Winters Apartments, Windmere I and II Apartments, we reviewed the existing bills. For Fox Creek irrigation is separately metered, while Windmere's anlaysis required that we average the water usage in months without irrigation to estimate annual residential use. We established a Zero Net Water goal by taking the acreage of each site and calculating the average rainfall the site receives in gallons. From this Zero Net Water analysis we learned that all landscape irrigation would need to be removed except the water provided by the Nexus ReUse from the Laundromat.



Winters Residential Use (gal/year)	2,932,538
Winters Landscape Water Use (gal/year)	3,689,491
Total Annual Water Use	6,622,029
Zero Net Water Budget	2,150,887
Reduction of Residential Load to Match ZNW Budget, Assuming Xeriscape	27%





Windmere I Residential Water Use (gal/year)	3,208,172
Windmere I Landscape Water Use (gal/year)	593,164
Windmere II Residential Water Use (gal/year)	2,817,716
Windmere II Landscape Water Use (gal/year)	2,104,872
Combined Windmere I and II Site Water Use	8,723,924
Zero Net Water Budget	3,930,729
Reduction of the Residential Load to Match ZNW Budget, Assuming No Imported Landscape Water	35%

We established at each project a total amount of water necessary to be saved, ranging from 27-35% to match the exact amount of water that falls on the site.

Our next step was to analyze the feasibility of meeting the water budget by establishing a current baseline water usage per person, per year. Using the policy and research-established occupancy rate for CTCAC-funded affordable housing of 1.5 people per bedroom, we deduced the water use of each person. The Davis, CA Windmere I Apartments occupants were using approximately 53 gallons/person/day and the newer Windmere II Apartments were using 45 gallons/person/day. The older project, Winters Apartments in Winters, CA twenty-two miles away is using approximately 70 gallons/person/day. Winters Apartments is 33 years old and most fixtures have not been replaced since the original construction, while Windmere I and II were built in 1999 and 2003, and have also been partially retrofitted for lower water use fixtures.

Windmere Phase I Existing Residential Water Use				
	Number of Units	Gallons per Day	Gallons per Year	Gallons Per Apt Type
2 Bed Demand	33	159	58,035	1,915,155
3 Bed Demand	15	239	87,053	1,305,788
Total Approximate Annual Water Use (Gal)				3,220,943
*Model Corrected to Assume 53 gallons per person with CTCAC Occupancy				

Windmere I Apartments

Windmere Phase II Existing Residential Water Use				
	Number of Units	Gallons per Day	Gallons per Year	Total Approximate Annual Water Use (Gal)
2 Bed Demand	58	135	49,275	2,857,950
*Gallons/day assumes 45 gallons per person with CTCAC Occupancy				

Windmere II Apartments

Winters Existing Residential Water Use				
	Number of Units	Gallons per Day	Gallons per Year	Gallons Per Apt Type
1 Bed Demand	18	**105.0**	**38,325**	**689,850**
2 Bed Demand	20	**210.0**	**76,650**	**1,533,000**
3 Bed Demand	6	**315.0**	**114,975**	**689,850**
Total Approximate Annual Water Use (Gal)				**2,912,700**
*Model Corrected to Assume 70 gallons per person with CTCAC Occupancy				

Winters Phase I

In order to establish a Zero Net Water budget, we first established the principal that all irrigation excepting that supplied by the Nexus eWater treatment system would be eliminated with a new no-irrigation landscape of fruit trees and native plants. With the imported water irrigation budget entirely removed, the remaining task was to size the water demand to that established by the East Bay Municipal Utility District in Oakland's affordable housing stock, 40 gallons/person/day.

With the July 1st release of the Green Point Rated Calculator, we have a fixture-by-fixture calculator showing the average water consumption of an average house in 2014. Redwood Energy was the lead researcher, in partnership with the technical leads from the CEC, LBNL, EPA WaterSense, Florida Solar Energy Center and researchers from AquaCraft, Water Demand, KEMA, TRC, Davis Energy Group, Masco, ReNewability, Aim4Sustainability and ShowerSense.

This calculator established that a National Baseline for average households is rounded to 48 gallons per day for a household without a clothes washer, as is the case for all apartments in the three Projects.

The Green Point Rated Residential Indoor Water Use Calculator for a Single Person							
Mayer, DeOreo, Van Decker, Sherman, Lutz, Schein, Klein, Sherman, Dryden, Zhang, Brook, Stone, Selover, Dakin, Parker, Fairey, Ownby and Armstrong							
Type of Fixture	Percentage of Fixture Use Which is Hot Water (Mains=58F)	Baseline Flowrates (REUWS 1999 & 2014) [Gallons / min.]	Duration of Use (REUWS, 1999) [min. / Occupant / Day]	Fixure Uses Per Day (REUWS, 1999) [Uses / Occupant]	Breakout of Water Use: Hot, Cold, and Total		
					Single Occupant Daily Hot Water Use [Gal. / Occ. / Day]	Single Occupant Daily Cold Water Use [Gal. / Occ. / Day]	Single Occupant Daily Total Water Use [Gal. / Occ. / Day]
Shower - Actual Bathing Use	63%	2.20	6.50	0.75	6.79	3.94	10.73
Shower - Structural Waste (per Lutz and Sherman)	71%	2.20	0.91	0.75	1.07	0.44	1.51
Shower - Behavioural Waste (47 seconds of shower duration Sherman 2014 with LBNL/Lutz data)	71%	2.20	0.78	0.75	0.92	0.37	1.29
Bathroom Faucets	57%	1.3	5.5	0.31	1.26	0.94	2.20
Bathroom Faucets - Structural Waste (Selover 2010)	57%	1.3	2.6	0.31	0.61	0.46	1.06
Kitchen Faucets	57%	1.3	5.8	0.69	2.98	2.23	5.21
Kitchen Faucets - Structural Waste (Selover 2010)	57%	1.3	2.3	0.69	1.18	0.88	2.06
Toilets	0%	2.6	---	5.0	0.00	13.00	13.00
Dishwasher	100%	--	---	1 gallon/day	1.00	0.00	1.00
Leaks	12%	--	---	9.5 gallons/day	1.14	8.36	9.50

	TOTALS		
	Single Occupant Daily Hot Water Use [Gal. / Occ. / Day]	Single Occupant Daily Cold Water Use [Gal. / Occ. / Day]	Single Occupant Daily Total Water Use [Gal. / Occ. / Day]
Without Clothes Washer	16.9	30.6	47.6

We then used the calculator and established that we may be able to drive water use as low as 29 gallons/person/day using the maximum water efficiency measures currently available—Niagara flapperless 1.3 gpm toilets, .5gpm bathroom faucets, 1.0 gpm kitchen faucets, and Evolve 1.5gpm thermostatic showerheads. (see next page)

Rather than assume the most optimistic savings of 29 gpd predicted by the Green Point Rated Calculator, for the purposes of this proposal we use a relatively conservative post-retrofit estimate **40 gallons/person/day**. A post-retrofit goal of 40 g/p/d has been proven by the Oakland Housing Authority with their aggressive water savings program coordinated with the East Bay Municipal Utility District, perhaps the most conservation oriented water utility in California. Proving out whether the Green Point Rated calculator accurately predicts even lower consumption than 40 gal/person/day will be one of the research objectives.

The Green Point Rated Residential Indoor Water Use Calculator for a Single Person

Mayer, DeOreo, Van Decker, Sherman, Lutz, Schein, Klein, Sherman, Dryden, Zhang, Brook, Stone, Selover, Dakin, Parker, Fairey, Ownby and Armstrong

Type of Fixture or Appliance and rated flow rate	Percentage of Fixture Use Which is Hot Water (Mains per Above)	Flow Rates Using Revised Fixtures and Standard California [Gallons / min.]	Duration of Use (REUWS, 1999) [min. / Occupant / Day]	Fixure Uses Per Day (REUWS, 1999) [Uses / Occupant]	Breakout of Water Use: Hot, Cold, and Total		
					Single Occupant Daily Hot Water Use [Gal. / Occ. / Day]	Single Occupant Daily Cold Water Use [Gal. / Occ. / Day]	Single Occupant Daily Total Water Use [Gal. / Occ. / Day]
Shower - Actual Bathing Use	63%	1.50	6.50	0.75	4.63	2.68	7.32
Shower - Structural Waste	71%	1.50	1.84	0.75	1.47	0.60	2.07
Shower - Behavioural Waste w/ Shower Warm Up	71%	0.12	0.78	0.45	0.03	0.01	0.04
Shower - Behavioural Waste w/ Tub Spout Warm Up	71%	1.50	0.78	0.3	0.25	0.10	0.35
Bathroom Faucets	57%	0.5	5.5	0.31	0.48	0.36	0.85
Bathroom Faucets - Structural Waste (Selover 2010)	57%	0.5	9.4	0.31	0.84	0.63	1.46
Kitchen Faucets	57%	1.0	5.8	0.69	2.29	1.72	4.01
Kitchen Faucets - Structural Waste (Selover 2010)	57%	1.0	4.1	0.69	1.61	1.21	2.82
Toilets	0%	1.28	---	5.0	0.00	6.40	6.40
Dishwasher	100%	--	---	1 gallon/day	1.00	0.00	1.00
Leaks	41%	--	---	9.5 gallons/day	1.14	1.67	2.81

	TOTALS		
	Single Occupant Daily Hot Water Use [Gal. / Occ. / Day]	Single Occupant Daily Cold Water Use [Gal. / Occ. / Day]	Single Occupant Daily Total Water Use [Gal. / Occ. / Day]
Without Clothes Washer	13.7	15.4	29.1

For estimating baseline Domestic Hot Water Use we reverted to Title 24 compliant Energy Pro software to establish consistent reporting with the rest of the energy models provided. However, we noted that the algorithm found in Equation RE-7 in the Alternative Calculation Method published for Title 24 software does not predict DHW by occupancy, leading to a likely underestimate of the increased water use in affordable housing—a 650 sf single bedroom apartment uses 25.8 g/p/d of DHW, while an 850 sf two bedroom apartment, with twice the occupancy, is predicted to use only 27.2 g/p/d of DHW, 5% more while occupancy is 100% more.

Equation RE-7 $GPD_I = 21.4 + 0.00679 \times CFA_i$

Where,

GPD_i = Average daily hot water consumption (gallons) of the i^{th} dwelling unit.

CFA_i = Conditioned floor area (ft^2) of the i^{th} dwelling unit. When actual conditioned floor area is greater than 2500 ft^2, 2500 should be used in Equation RE-7.

For post-retrofit DHW savings **we assumed a flat 32% energy savings** from Domestic Hot Water energy predicted by the Title 24 software to address the difference between the high flow fixtures used in RE-7, which is baselined on 1992 usage, and the DHW usage of the highest efficiency housing that can be currently built in 2014-2015. Given that each apartment is lowering its use from 70, 53 and 45 gallons to as low as 29 gallons/person/day but perhaps as high as 40 g/p/d, we adopted a flat 32% and hope to prove out the new Green Point Rated calculator with post-retrofit research.

Energy

For energy use we used standard Title 24 software to establish HVAC and DHW use, then entered the data into the California Utility Allowance Calculator to establish the amount of PV required for a Zero Net Electric offset. A summary is below, and the Econ-2 and CUAC print-outs are provide for back-up.

Type of Apt	Number of Apts	Electricity Savings	Fossil Fuel (Therms) Savings	Fossil Fuel (Therms) Remaining Under Improved Conditions	Equivalent kWh Use to Ofset Therms and Create 100% ZNE
1 Bed	18	6,229	4,090	2,571	75,330
2 Bed	20	4,700	4,516	3,039	89,043
3 Bed	6	970	4,516	965	28,275
Totals	44	11,899	13,122	6,575	192,648
	Retrofit Gas Savings in KWh (29.3 kWh/Therm)	**384,475**			
	Solar Offset	**330,550**			
	Total Post-Retrofit Energy Savings	**726,924**			

Type of Apt	Number of Apts	Electricity Savings	Fossil Fuel (Therms) Savings	Fossil Fuel (Therms) Remaining Under Improved Conditions	Equivalent kWh Use to Ofset Therms and Create 100% ZNE
2 Bed	33	(9,001)	9,507	3,498	102,489
3 Bed	15	(12,375)	6,548	1,733	50,766
Totals	48	(21,376)	16,055	5,231	153,255
	Retrofit Gas Savings in KWh (29.3 kWh/Therm)	**470,424**			
	Solar Offset	**251,096**			
	Post-Retrofit Total Electricity Savings	**700,144**			

Windmere Phase I Apartments, Davis, CA

Type of Apt	Number of Apts	Electricity Savings	Fossil Fuel (Therms) Savings with 32% DHW savings	Fossil Fuel (Therms) Remaining Under Improved Conditions	Equivalent kWh Use to Offset Therms and Create 100% ZNE
2 Bed	33	(12,697)	11,907	5,921	173,498
	Retrofit Gas Savings in KWh (29.3 kWh/Therm)	348,862			
	Solar Offset	278,274			
	Post-Retrofit Total Energy Savings	614,439			

Windmere II Apartments, Davis, CA

To establish the Energy Intensity of the DHW conserved through retrofits of the tank and fixtures, the following calculations were performed relying on the data from Title 24 for energy and water use, and assuming a 32% minimum savings in DHW consumption from fixture use. The energy savings in Therms were converted to kWh by multiplying therms by 29.3 for the site-based energy conversion to kWh.

Energy Intensity of Saved DHW Calculations	
Energy Savings of DHW (converted to kWh) using Tank Savings and 32% reduced DHW demand savings	216,263
Million Gallons of DHW Saved Per Year	657,214
Energy Intensity (EI) of the Saved DHW	0.33

Winters Apartments

Energy Intensity of Calculation for Saved DHW	
Energy Savings of DHW (converted to kWh) using Tank Savings and 32% reduced DHW demand savings	165,792
Million Gallons of DHW Saved Per Year	97,877
Energy Intensity (EI) of the Saved DHW	1.69

Windmere I

Energy Intensity of Saved DHW Calculations	
Energy Savings of DHW (converted to kWh) using Tank Savings and 32% reduced DHW demand savings	151,263
Gallons of DHW Saved Per Year	43,595
Energy Intensity (EI) of the Saved DHW	3.47

Windmere II Apartments

For the Emmissions Factor we were able to use published data for PG&E, but were not able to find data for SMUD and relied on the default provided.

PG&E Emissions Factor Summary

Emission Type	Emission Factor			Source
	Year	*Lbs CO_2 /MWh*	*Metric tons CO_2/MWh*	
Historical Emissions	2003	620	0.281	PG&E's third-party-verified GHG inventory submitted to the California Climate Action Registry (CCAR)[2] (2003-2008) or The Climate Registry (TCR) (2009-2011)
	2004	566	0.257	
	2005	489	0.222	
	2006	456	0.207	
	2007	636	0.288	
	2008	641	0.291	
	2009	575	0.261	
	2010	445	0.202	
	2011	393	0.178	
Future Emissions (estimated)	2012[3]	453	0.205	CPUC GHG Calculator, which provides an independent forecast of PG&E's emission factors as part of a model on how the electricity sector
	2013	431	0.196	
	2014	412	0.187	
	2015	391	0.177	
	2016	370	0.168	

[2] The 2003-2008 factors are in the Power/Utility Protocol (PUP) spreadsheet of PG&E's CCAR reports. The 2009-2011factors are in the Additional Optional Information tab of the Electric Power Sector (EPS) Report spreadsheet of PG&E's TCR report.

[3] PG&E's actual 2012 emission factor will be available in January 2014.